

VENTILATION
OF
SCHOOL HOUSES.



BOSTON:

1848.

J. H. EASTBURN.....CITY PRINTER.

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BOSTON, School Committee

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REPORTS
AND
OTHER DOCUMENTS
RELATING TO THE
VENTILATION
OF THE
SCHOOL HOUSES
OF THE
CITY OF BOSTON.



BOSTON:
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PREFATORY NOTE.

At a meeting of the School Committee, December 9, 1847, the Committee on Ventilation made their second and final Report, which was ordered to be printed.

At a subsequent meeting the following Order was passed :

“CITY OF BOSTON.

“*In School Committee, December 29, 1847.*

“*Ordered, That the Committee on Ventilation, be instructed to append to their late Report on Ventilation, such parts of their previous Reports on the same subject, and such special directions to the Masters, as they may think advantageous.*

“A true copy.

“Attest,

S. F. McCLEARY, *Secretary.*”

In February, 1846, a Sub-Committee of the School Committee, consisting of Messrs. Clark, Loring, and Brooks, was appointed, in the words of the Order, “to consider the subject of Ventilation of the School houses under the care of this Board, and to Report at a future meeting, some method of remedying the very defective manner in which it is at present accomplished.

“And said Committee are authorized to ventilate, as a matter of experiment, any two School houses in such manner as they may deem expedient.”

In December of the same year, (1846), this Committee made a Report, containing their views upon the subject, and the result of their investigations of the condition of the School houses, &c., from which the following passages, after undergoing some necessary revision, have been extracted.

It is believed, that these Reports, with their accompanying documents, now contain information upon all points necessary to be understood, in order to ventilate any School house in a perfectly satisfactory manner.

Boston, December, 1847.



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REPORT ON VENTILATION,

PRESENTED TO THE SCHOOL COMMITTEE, DEC. 30th, 1846.

THE Committee, to whom the subject of Ventilation was referred, ask leave to

R E P O R T:

That, during the early part of the present year, they have visited, and carefully examined, all the School houses under the care of this Board, in obedience to the Order herewith prefixed.

Your Committee do not deem it advisable or necessary, to enter upon the discussion or description of the various systems of ventilation which have been proposed from time to time, or to consider their comparative merits. Many of them, no doubt, are excellent; and, if properly arranged, must be efficient. But we believe, that the distinguishing excellence of any method must consist in, and be in exact ratio to, its adaptedness to meet the peculiar requirements of each case to which it is applied. Nor do we think it possible for any plan to succeed, which does not include the architecture and situation of the structure to be ventilated, and the number and necessities of those who are to occupy it. Nevertheless, a suitable attention to the laws of life,

and of the physical agents which are concerned with it, will always ensure ready indications of the best course of procedure, and, at the same time, furnish a basis whereon to found it, which will be sufficiently firm and comprehensive. Your Committee, therefore, desire to call the attention of this Board to the consideration of such general and well-established Physiological and Philosophical principles, as have a distinct and intimate relation to the subject of this Report, or may be useful in its elucidation.

In doing this, there are two things of which they hope to satisfy the Board.

First. The necessity of a system of Ventilation, which shall furnish, for all the pupils in the Public Schools of Boston, at all times, an abundant supply of an atmosphere entirely adapted, in its purity and temperature, to the purposes of respiration.

Secondly. The entire failure of the measures *heretofore* adopted to accomplish this desirable end.

The function of Respiration is that process, by whose agency and constant operation, the atmospheric air is admitted to the internal surface of the lungs, for the purpose of effecting certain changes in the blood which are as essential to the continuance of life, as to maintain the integrity of the bodily organs. During this process, the air is constantly losing its oxygen, which is carried into the circulation, while, at the same time, it is becoming overcharged with the carbonic acid gas, which is continually thrown off from the lungs by respiration. This effete and deadly poison spreads itself rapidly into *all parts* of the room.

“M. Lassaigne has shown, by a series of investigations, that, contrary to a common opinion, the air in a room which has served for respiration without

being renewed, contains carbonic acid alike in every part, *above* as well as below; the difference in proportion is but slight; and where appreciable, there is some reason to believe that *the carbonic acid is in greater quantity in the upper parts of the room*. These experiments establish the very important fact, that *all* the air of a room must be changed in order to restore its purity.”*

LeBlanc—who examined many public and private buildings, in France and elsewhere—speaking of the Chamber of Deputies, where sixty-four cubic feet of fresh air per minute were allowed to each individual, states, that of 10,000 parts escaping by the ventilator, twenty-five were carbonic acid; while the quantity of this gas ordinarily present in the atmosphere is but $\frac{4}{10000}$.

Dr. Wyman makes the following remarks on this point: “Although carbonic acid is a much heavier gas than atmospheric air, it does not, from this cause, fall to the floor, but is equally diffused through the room. If the gas is formed on the floor, without change of temperature, this diffusion may not take place rapidly. In the celebrated *Grotto del Cane*, carbonic acid escapes from the floor, and rises to a certain height, which is pretty well defined to the sight on the walls; below this line, a dog is destroyed, as if in water; above it, he is not affected. An analysis of the air above and below a brazier has been made, and it was found equally contaminated,—the former containing 4.65 per cent., and the latter 4.5 per cent. of carbonic acid.

“From the experiments of M. Devergie, who has devoted much attention to the poisonous effects of

* Silliman's Journal, for September, 1846.

these gases, it appears, that the heat disengaged from the combustion of charcoal, produces an equable mixture at all elevations in the apartment; and this state of things continues *as long as the room remains warm*; but after twelve hours or more, the carbonic acid sinks, and while that near the ceiling contains only a seventy-eighth, that near the floor contains nearly four times as much, or a nineteenth.”*

If further proof be needed to establish this position, we have other testimony. It is known that a considerable quantity of vapor is discharged from the lungs during respiration. With regard to this, Mr. Tredgold says: “If the air did not contain this mixture of vapor, it would not rise when expelled; and we have to admire one of those simple and beautiful arrangements, by which our all-wise Creator has provided against the repeated inhalation of the same air; for a mixture of azote, carbonic acid gas, and vapor, at the temperature it is ejected, is much lighter than common air even at the same temperature. Hence, it rises with such velocity, that it is entirely removed from us before it becomes diffused in the atmosphere. But as all gaseous bodies and vapors intimately mix when suffered to remain in contact, we see how important it is that ventilation should be continual; that the noxious gases should be expelled as soon as generated; and that the ventilation should be from the upper part of a room.”†

If, to the foul effluvia ejected from the lungs, and accumulating in an apartment as badly ventilated as one of our School rooms, be added the fouler matter thrown into the air from the insensible perspiration of so many individuals, many of whom are of

* Practical Treatise on Ventilation, p. 77.

† Tredgold on Warming and Ventilating Buildings, p. 70.

uncleanly habits in person and apparel, it is apparent, that, in a very limited period of time, the air in a perfectly close room would become so entirely unfit for respiration, that, to all who were exposed to its influence, submersion in water could not be more certainly fatal.

The terrible effects of continued exposure to carbonic acid gas in a concentrated form, have been graphically described by Howard, in his account of the Black Hole of Calcutta. Of one hundred and forty-six persons, shut up in this place, for only ten hours, without any other means of ventilation than one small opening, but twenty-six were found alive, when it came to be opened; and most of these suffered afterwards from malignant fevers.

The fainting of feeble persons in crowded assemblies, and the asphyxia so often produced in those who descend into deep wells without suitable precaution, are familiar examples of the same noxious effects of this poison.

It has been usually estimated, that every individual, by respiration, and the various exhalations from the body, consumes or renders unfit for use, at least from four to five cubic feet of air per minute. This is probably a low estimate; but authors of good repute differ considerably on this point. Mr. Tredgold's remarks, in this connection, are interesting and pertinent. "The Physiological Chemists," says he, "have placed in our hands a more accurate means of measuring the deterioration of air in dwelling-rooms, than by the best eudiometer; for they have shown, by repeated experiments on respiration, that a man consumes about thirty-two cubic inches of oxygen in a minute, which is replaced by an equal bulk of carbonic acid from the lungs. Now, the

quantity of oxygen in atmospheric air is about one fifth ; hence it will be found, that the quantity rendered unfit for supporting either combustion or animal life, by one man, in one minute, is nearly one hundred and sixty cubic inches, by respiration only. But a man makes twenty respirations in a minute, and draws in and expels forty inches of air at each respiration ; consequently, the total quantity contaminated in one minute, by passing through the lungs, is eight hundred cubic inches.* The other sources of impurity, which should be considered, will increase the estimate to the amount above stated. The amount of vapor discharged from the lungs, and thus added to the impurities of the air, is said to exceed six grains per minute. It has also been shown, that air which has been some time in contact with the skin, becomes almost entirely converted into carbonic acid.†

In estimating the amount of fresh air to be supplied we ought not merely to look at what the system will tolerate, but that amount which will sustain the highest state of health for the longest time. Dr. Reid recommends at least ten cubic feet per minute, as a suitable average supply for each individual ; and states that his estimate is the result of an “ extreme variety of experiments, made on hundreds of different constitutions, supplied one by one with given amounts of air, and also in numerous assemblies and meetings, where there were means for estimating the quantity of air with which they were provided.”‡

These calculations refer to adults ; but the greater delicacy of the organization of children, and their feebler ability to resist the action of deleterious agents,

* Tredgold on Warming and Ventilating Buildings, p. 69.

† Cruikshanks makes it twenty-three grains per minute.

‡ Illustrations of Ventilation, p. 176.

together with their greater rapidity of respiration, demand for them at least an equal supply. Proceeding upon this basis, and multiplying the amount required per minute, by the minutes of a school session of three hours, we have eighteen hundred cubic feet for each pupil; and for two hundred and fifty pupils — the average maximum attendance in one of our large school rooms, — 450,000 cubic feet, as the requisite quantity for each half-day. The rooms contain about 22,500 cubic feet only: so that a volume of air, equal to the whole cubic contents of each room, should be supplied and removed, in some way, ten times every three hours, in order to sustain the air in them at a point which is perfectly healthy and agreeable. For such a purpose, the present means are so entirely inadequate, that it was found that the air of a room became tainted in ten or fifteen minutes. In ordinary cases, four per cent. of the air expelled from the lungs is carbonic acid. The presence of five or six per cent. will extinguish a lamp, and with difficulty support life. It is therefore certain, that the air would become deprived of all its best properties in one school session.

The very earliest impressions received by your Committee, in their visits to the school houses, satisfied them of their lamentable condition in regard to ventilation. In some of them, they found the air so bad, that it could be perceived before reaching the school rooms, even in the open entries; for we noticed that the clothes and hair of the children who passed us on the stairs were perceptibly impregnated with the foetid poison. And these circumstances existed in houses, whose open windows testified, that the Masters had endeavored to improve the atmosphere by all the means placed at their disposal. To this

custom, — *that of opening windows in school hours*, — the Instructors are *compelled* to resort for relief; this expedient being certainly the lesser of two very great evils. Yet this dangerous and injurious practice only mitigates the evils of bad air, by creating others. It produces colds and inflammatory complaints, and the air still remains impure, offensive, and highly deleterious; sufficiently so, to affect the delicate organization of childhood, to blight its elasticity, and destroy that healthful physical action, on which depends the vigor of maturer years.

We have referred to some of the more violent and sudden effects of exposure to air highly charged with these noxious gases. There are others, which, although more remote and hidden, are not therefore of less importance. The grave consequences of long-continued exposure to an atmosphere but a little below the standard of natural purity, although not immediately incompatible with life, can hardly be overstated. These effects are often so insidious in their approach, as scarcely to attract notice; it is therefore the more necessary to provide against them in advance.

Children, who are confined in the atmosphere of these schools, soon lose the ruddy and cheerful complexions of perfect health which belong to youth, and acquire the sallow and depressed countenances which might reasonably be expected in over-worked factory operatives, or the tenants of apartments which are never blest by the cheerful sun or the reviving air.

Although the atmosphere in the different school houses varied very much in particular cases, either owing to the time of the visits, or from the amount of attention and intelligence of the Masters, yet in

none of them was it at all satisfactory; not one of them was furnished with any useful or systematic means of ventilation.

All of the rooms are provided with registers, in or near the ceiling, ostensibly for the purpose of discharging the foul air, but which are entirely useless. The openings through the roof into the open air, where they exist, are so small, as to be quite inadequate to relieve the attics; so that the bad air must accumulate there, and, after becoming condensed, be gradually forced back again, to be breathed over by the same lungs which have already rejected it. The condition of the apartments, after undergoing a repetition of such a process, for any length of time, can easily be imagined.*

It may be deemed a matter of surprise, that the subject of ventilating our school rooms has not long ago received the consideration necessary to remedy, or even to have prevented altogether, the evils of which we at present complain. But these evils have not always existed. It should be recollected, that the stoves and furnaces now in common use, are of comparatively modern date; and moreover, that the ample fireplaces which they have displaced, always proved perfectly efficient ventilators, although, it is true, somewhat at the expense of comfort and fuel. But in closing the fireplaces, and substituting more economical methods of warming, evils of far greater magnitude have been entailed upon us.

It is evident, that, in order to carry into operation any complete system of ventilation, there must be connected with it some apparatus to regulate the *temperature* of the air to be admitted, as well as to

* See Diagram, p. 15.

ensure its ample supply. Your Committee have accordingly examined, with much care, this part of the subject.

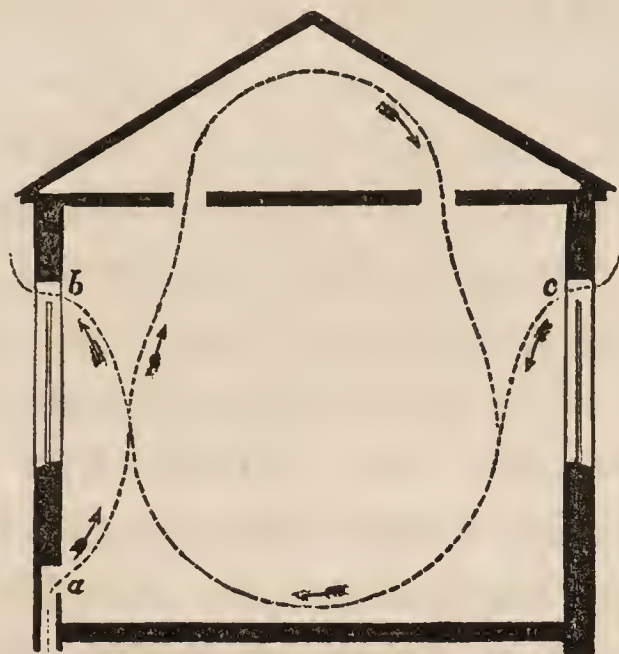
A majority of the buildings are furnished with "hot-air furnaces," situated in the cellars; the remainder with close stoves, placed in the school rooms themselves.

In our endeavors to introduce in this department, the improvements which seemed to us absolutely essential, we have encountered serious difficulties. Most of the furnaces possess great heating powers, —indeed much greater than are necessary, if the heat generated by them were properly economized, or could be made available;—but, as now constructed, they are worse than useless, consuming large quantities of fuel, and, at the same time, so overheating the air which passes through them, as to deprive it of some of its best qualities, and render it unsuitable for respiration, although it is difficult to define, with precision, or by analysis, the changes which take place in air subjected to the action of metallic surfaces, at a high temperature.

It has been ascertained, by repeated examinations, that the temperature of the air, when it arrives at the rooms, through the very small warm air pipes now furnished, is often as high as 500° and 600° Fahrenheit. Of course, it is entirely impossible to diffuse air, thus heated, in the parts of the room occupied by the pupils. Much of it passes rapidly out of the windows, which may be open; the rest to the ceiling, where it remains until partially cooled, gradually finding its way down by the walls and closed windows, to the lower parts of the room. The consequence is, that while much more caloric is sent into the apartment than is requisite, many of the pu-

pils are compelled to remain in an atmosphere which is at once cold and stagnant.

A reference to the subjoined diagram will explain at once, the present state of the Ventilation of the school houses.



- a. Heated air from furnace.
- b. Hot air escaping through open window.
- c. Cold air entering through open window.

These difficulties are inherent in the structure of the furnaces; and they cannot well be obviated, by any other method than by rebuilding or replacing them.

The boxes, which admit the cold air to the furnaces, are much too contracted; some of them being only a few inches square, when their capacity ought to be nearly as many feet. The air enters the "cold air" chamber of the furnace, *at its top*, whence it is intended to be carried down between thin brick walls, (which *should be cold*, but which are often heated to 300° Fahrenheit,) to the lower part of the furnace, and thence into the "hot air" chamber, and so on to the rooms above. It is obvious that the "hot-air" chamber must be heated to a temperature far beyond that of the "cold air" chamber, in order to

compel the air, against its own natural tendencies, to pass into it with any velocity or volume, and the very attempt to accomplish this, almost defeats itself; as, by driving the fire for this purpose, the "cold-air" chamber becomes still hotter, so that at last the contest is decided only by the greater calorific capabilities which the iron plates possess over the brick wall. At any rate, the temperature of the iron fire pot is frequently raised to a *red* or even a *white heat*, by running the furnaces in the ordinary way. This soon destroys them, and they require consequently to be frequently renewed.

Your Committee are satisfied, that the present state of the school houses daily impairs the health of the pupils and Instructors, and the efficiency of the schools for the purposes of instruction; that its continuance will produce, not only immediate discomfort and disease, but, by its effect upon the constitutions of the children, who must pass in them a large portion of those years most susceptible to physical injury, will directly and certainly reduce the amount of constitutional vigor hereafter to be possessed by that large mass of our population, which now and hereafter is to receive its education in these schools.

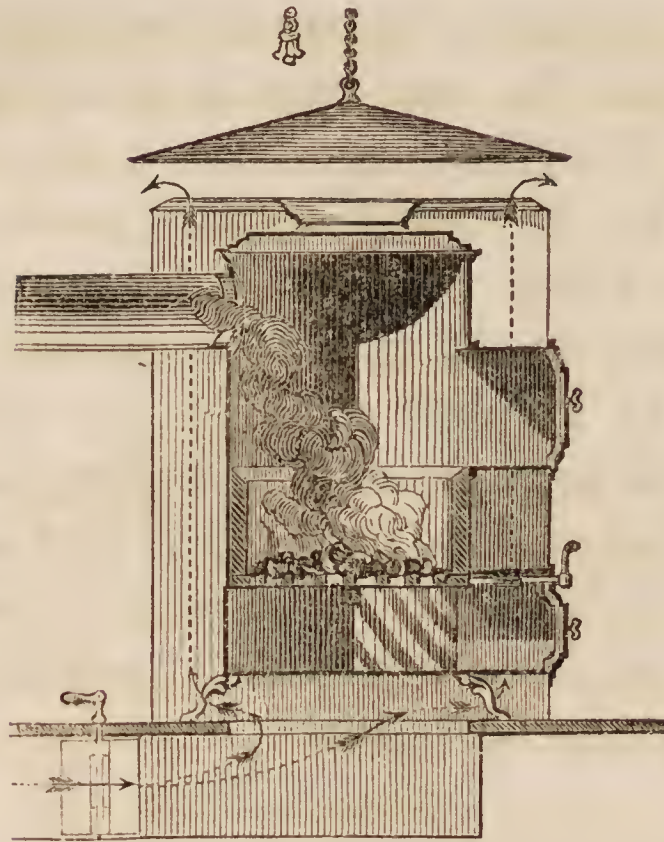
With regard to the expenditure necessary to complete the improvements which your Committee recommend, they are of the opinion, that the alarming evils referred to in this Report, may be at once, and entirely and permanently removed, at an average expense of two hundred and fifty dollars for each school house, now built. And by availing ourselves of some recent improvements, which have been made in this City, in the form and construction of a

part of the necessary apparatus, we hope to reduce its cost, and at the same time increase its efficiency.

But the Committee have no doubt, from actual experience of the effects already produced by the experiments which they have superintended, in two school houses, that all the expense of any alterations which may be required, to warm and ventilate our school houses upon rational principles, and in a thorough manner, will be more than saved to the City, in two or three years, in the item of fuel alone, if the system which they propose is adopted, and faithfully carried into operation.

[The Report then details some experiments upon the Eliot School house, and describes the plans adopted to ventilate the Endicott School house. These can be omitted here, as all their essential features are comprised in the diagrams which illustrate the final Report. The following drawing is given to show the mode adopted for introducing and supplying warm air to the houses and apartments, such as recitation rooms, primary school rooms, &c., which we found heated by *close stoves*.]

The drawing (page 18) exhibits a section of a stove, enclosed by an outward casing of sheet iron, or tin, so as to make a large chamber around it, into which the fresh air may be admitted and warmed. The arrows show the course of the air through the stove. It is supplied from an air-box opening under the inner cylinder and connecting with the fresh air by means of an aperture cut through the outer wall of the building. The suspended top regulates the temperature, and gives a lateral direction to the warm air.



The Committee propose the following as an outline of the best general plan for warming and ventilating the school houses.

1. The air must be taken from a pure source and from the higher parts of the building, if any impurities are found to exist near the surface of the ground.

2. In order to ensure a constant and abundant supply, the air shaft when carried above the building must be surmounted with a cowl or hood of some kind, with its mouth turned *towards the wind*.

3. The fresh air should in all cases be carried *entirely beneath the furnace*. If the cellar is wet and the situation low, the underground culvert, or channel, should be of brick, laid in cement.

4. The furnace chamber should be so large that it can be entered at any time, without the necessity of taking down walls, for the purpose of repairs, or to observe the temperature. A large earthen pan for the evaporation of water should not be omitted. This should be kept perfectly clean, and the water required to be frequently changed.

5. A thermometer should be constantly at hand, and the *temperature in the warm-air chamber should never be allowed to exceed that of boiling water*. A still lower temperature is often desirable. If this point is secured, the hot air can be conducted with perfect safety into any part of the building.

6. The openings for the admission of the warm air into the rooms, should be as numerous as possible. The long platform occupied by the teachers, might be made an excellent diffusing surface.

7. Openings of ample size must be made in the highest points of the ceiling, to be connected at the top of the roof with a turn-cap or louvre, the former being always surmounted with a vane. It is better that the ceiling should be perforated at its centre, and there is no objection to running the ventilating shaft, at first, horizontally, if the perpendicular and terminal portion of it is of considerable length.*

8. *It is well to have a power of some sort, within the apparatus at its top*, for the purpose of compelling constant action and of increasing the force of the apparatus, whenever the state of the weather, or the crowding of the room, renders it necessary. For this purpose, the most convenient and economical means are furnished by a gas burner, an argand lamp, or a stove; and one of these may be in constant readiness for use, when neither the velocity of the wind, nor the low temperature of the external atmosphere, are sufficient to produce the desired effect.

9. All the openings and flues for the admission of pure air, and the discharge of the foul air, should be of the *maximum* size; that is, they should be calculated for the *largest numbers* which the apartment is ever intended to accommodate.

* See page 31 of Final Report.

10. Valves must be so placed in the flues as to be easily regulated without leaving the rooms into which they open.

11. The best average temperature for school-rooms, is from 64° to 68° Fahrenheit; this range including that of the healthiest climates in their best seasons.

12. For the purpose of summer ventilation, and for occasional use in moderate weather, fireplaces of good size may be constructed in the new houses. They should always be double, and furnished with chambers communicating with the open air.

13. *Each story* of the building must be warmed by a Furnace or Stoves, appropriated exclusively for its own use.

Before concluding this Report, your Committee cannot avoid expressing the confident belief, that a suitable consideration of the evils, whose existence they have proved, is only necessary to ensure their speedy removal.

It has been already shown, that healthy blood is essential to the proper vital action of the organs of the human body, and that the healthy condition of the blood, depends entirely upon the act of respiration; that, to breathe air deprived of its oxygen, or containing anything which prevents the necessary changes in the blood, is to breathe disease and death.

We can subsist without food, for days, or even weeks. We might spend our whole lives, under some circumstances, without clothing or shelter; and yet, while almost all the energies of civilized society are exerted to obtain these things, in their various forms of comfort or luxury; with a most surprising disregard of the dictates of common sense, and a

want of discretion which is no where else exhibited, we exclude from our best houses, by every means in our power, that vital fluid, without which no respiratory being can exist for a single hour.

HENRY G. CLARK,
EDWARD G. LORING,
CHARLES BROOKS.

Boston, December 30, 1846.

CITY OF BOSTON.

In School Committee, December 30, 1846.

Ordered, That the Committee on Ventilation be and hereby are directed to adapt to each School room of the Common Schools such apparatus, if any, as may be required to secure to them proper ventilation in Winter and Summer, and make such alterations and arrangements of the furnaces as may be required.

Attest,

S. F. McCLEARY, *Secretary.*

In order to obtain the requisite means for carrying out the intentions of the School Board, the Committee on Ventilation memorialized the City Council. The subject was referred to a Special Joint Committee, who made thereupon a Report, as follows :

The Joint Special Committee to whom was referred the petition of the Sub-Committee of the School Committee, asking an appropriation to improve the ventilation of the Grammar School Houses, have attended to the subject, and ask leave to

R E P O R T .

The petitioners appeared before the Committee, and set forth the great importance that attaches to the subject of having pure air where great numbers are congregated—especially where those masses are constituted of children. They stated that in two of the Grammar School Houses, they had caused a ventilating apparatus to be constructed, which had been in operation nearly a year.

The experience of this period authorized them to state, first, that the air of the rooms had been greatly improved,—and in the second place, that the expense of warming the rooms was diminished one half, besides a great saving in the consumption of the castings of the furnace.

Such were the representations of the petitioners.

In order to be fully satisfied, the Committee visited the Endicott School, where the apparatus was in operation. The day was exceedingly wet and disagreeable, and yet the air of the rooms was found in an unobjectionable condition. The masters fully sustained the representations of the petitioners ; and

from their statements, as well as from their own observations, the Committee were satisfied of the beneficial effects of said apparatus.

In order, however, to have a more full investigation of the matter, the Committee, on a subsequent day, visited the Johnson School and the Boylston School. The day was dry and cold, and they found the air in the Johnson School in a tolerably good condition. This is a girls' school; and it is well known that the pupils in such schools are neater, and attend in cleaner and more tidy apparel, than the pupils in the boys' schools.

In the Boylston School, however, the Committee found the air very disagreeable and oppressive; and they could not but feel the importance of executing some plan of relief.

From the earnest representations of the petitioners, and from the result of their own examination, the Committee are of the opinion that the prayer of the petitioners ought to be granted; and they therefore recommend the passage of the following order; all which is respectfully submitted.

BILLINGS BRIGGS, *Chairman.*

Ordered, That the sum of *Four Thousand Dollars* be appropriated for the purpose of improving the ventilation of the Grammar School Houses—the same to be expended under the direction of the Joint Committee on Public Buildings—and be charged to the appropriation for School Houses.

In Common Council, Jan. 21, 1847.

Passed.

Sent up for concurrence.

GEO. S. HILLARD, *President.*

In the Board of Aldermen, Jan. 25, 1847.

Read and concurred.

JOSIAH QUINCY, JR. *Mayor.*

FINAL REPORT, ETC.

In School Committee, December 9, 1847.

THE Committee upon Ventilation respectfully

R E P O R T :

That in obedience to the order of this Board, and in pursuance of the plans laid before it in a former Report, your Committee have diligently applied themselves to the duty of ventilating the School Houses—a labor, whose difficulties, could they have been fully anticipated, might have prevented its accomplishment, at least by the members of this Committee. Although the members of the building Committee of the City Council have personally extended to us every reasonable courtesy, yet we cannot avoid the impression that the provisions of the Charter which deprive this Board of the control of the plans of the School Houses were framed with a very unwise disregard of the best interests of the Schools.

But notwithstanding the intrinsic difficulties of this undertaking, increased as they have been by the causes last named, your Committee cannot deny that it is with much satisfaction they now announce its completion. For we think it is no more than just to express our sincere opinion that the Grammar School Houses of Boston are now in a better condition, in respect to their ventilation, than any other public Schools in the world.

We have said that the work was complete. It is so substantially—for although many things still require to be done, in order to make every house in

all points equal with the best, yet, with the examples we have given, and the plans and specifications we shall submit, accompanying this Report, it is a mere mechanical work, as time and opportunities offer, to make each one in all points all that can be desired.

The plans, to which we refer, have been adapted in various ways, and with a variety of apparatus, as the circumstances in each case seemed to require, to sixteen Grammar School Houses, the building occupied by the High and Latin Schools, and besides these, to twenty-five large rooms used for Branch or Primary Schools. To *all* of these we have caused to be affixed the necessary flues, tops, and other apparatus for *discharging the foul air*; and they require nothing more for that purpose. We have altered, enclosed, or rebuilt, twenty-one stoves and furnaces, and set and supplied with the ducts, valves, &c., twenty-six of the new ventilating stoves, hereinafter described. A few houses still require stoves or furnaces or alterations of the same, of which a list is herewith appended.

The diversity of arrangement and the modifications in our plans into which we have been compelled by circumstances, have had their advantages, and enabled us to arrive at the best results, and to satisfy ourselves entirely in regard to the particular *set of apparatus* which we can recommend with confidence for future use as decidedly the most effective and convenient.

We have therefore furnished drawings and specifications of the set of apparatus which we recommend.

Furnaces.—The only Furnaces belonging to the School Houses which we have thought worth rebuilding are those of Mr. Preston. They are very substantial, require but little repairing, and are easily managed. They are open to sufficient objections,

however, we think, to make it undesirable to furnish any more where new ones are to be supplied; and they are simply these: The whole radiating surface is of heavy cast iron: it is therefore slow in becoming warmed so as to affect the air chamber; and the furnaces, for the same reason, are not economical as consumers of fuel. The fire-place is of brick, and in this respect it is very much superior to most other furnaces in which the iron fire pot itself is made the principal means of heating the air.

The other Furnaces which have been in use in some of the houses are so objectionable, on account of the frequent bursting of their pots and the escape of the deadly gas into the air chamber, as well as for other reasons, that we have thought the matter of sufficient importance to be made the subject of a special communication to the Committee of Public Buildings.

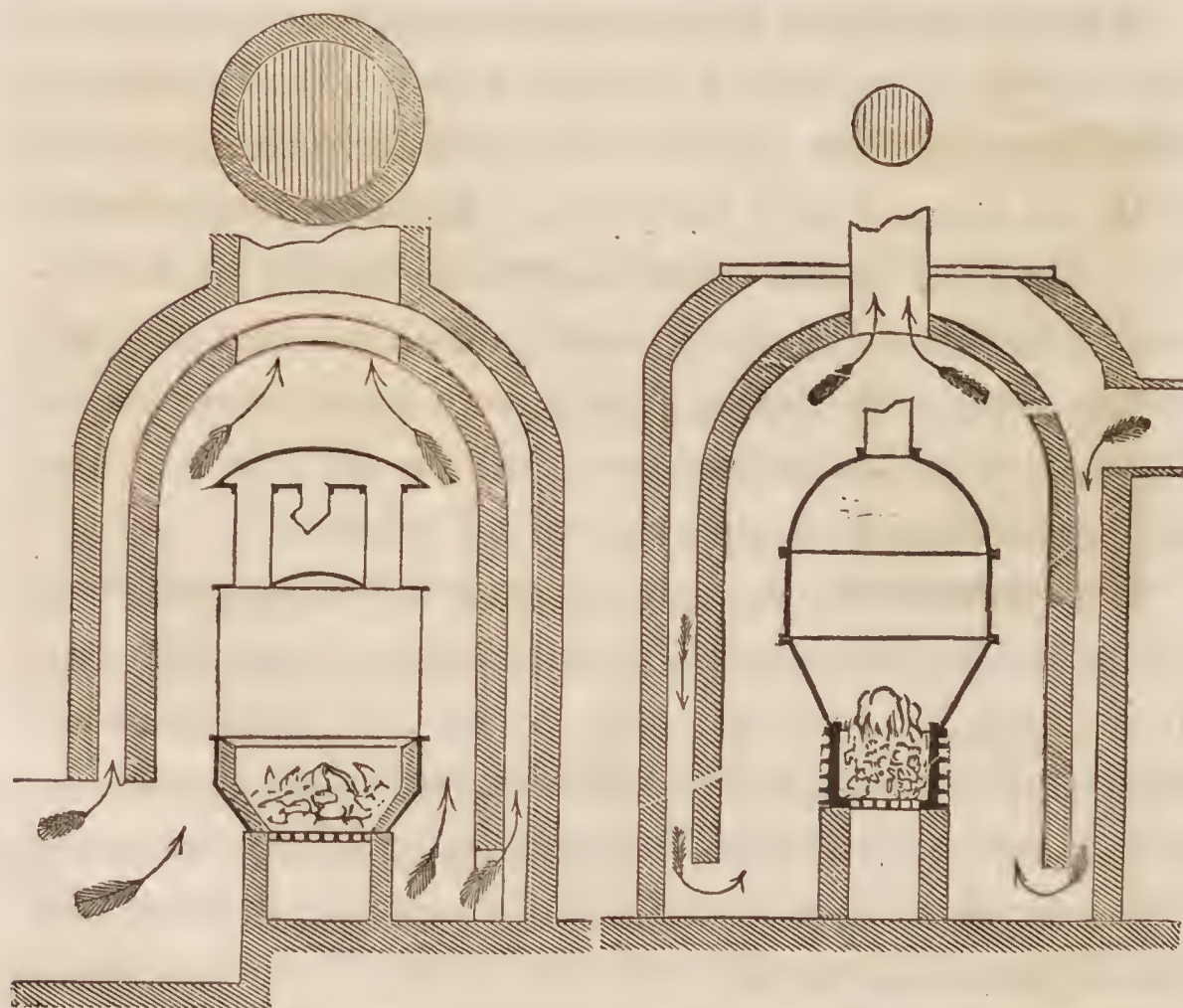
Your Committee have made themselves acquainted not only with all the Furnaces which have been manufactured in this place, and its neighborhood, but with all those which have been exhibited here recently. Most of them show much ingenuity of contrivance and excellence of workmanship; but are all, so far as we can judge, inferior in many respects, to the one, a model and plans of which we now exhibit, and recommend as superior to all others.*

It is simple in its structure, easily managed, will consume the fuel perfectly, and with a *moderate* fire. It is fitted for wood or coal. The fire place is broad and shallow, and is lined with soapstone or fire-brick, which not only makes it perfectly safe and durable, but modifies very materially the usual effect of the fire upon the iron pot.

The principal radiating surfaces are wrought iron, of a suitable thickness for service, while at the same

* Invented by Mr. Chilson. (See page 28.) Also, Appendix, D.

time the heat of the smallest fire is communicated immediately to the air chamber. The mode of setting this Furnace we consider essential; more especially the plan of admitting the air to the furnace at its lowest point, as it then rises naturally into the apartments above. This process commences as soon as the temperature is raised even a single degree. The outer walls remain cold; the floor above is not endangered, and the whole building is rapidly filled with an atmosphere which is at once salubrious and delightful. The proprietor of this Furnace very liberally offered to make such improvements upon its original form as your Committee thought necessary or desirable, at his own cost. He has also allowed one to be set in the Mayhew School House under our direction, where it may be seen in contrast with one of the old furnaces set in the old way.*



Mr. Chilson's.

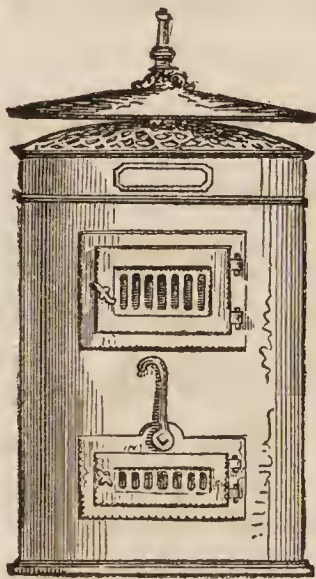
Section of Old Furnace. See p. 15.

* Since the above was read, the proprietors of the old furnace have replaced the old pot, (which had cracked) and enlarged the air box to three times its former size.

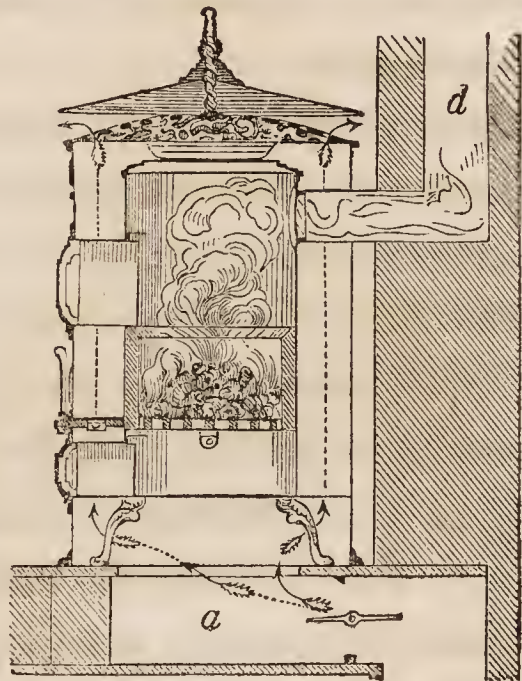
The *cold-air channel* to this furnace is *four feet* by *nearly two*—and the *warm-air flue*, which is of brick, lined with cement, is about *three feet*, by *one and a half*. (See Appendix D.)

For the houses which we found without the Hot Air Furnaces, as also for the Recitation and other single Rooms, the invention of a Stove which should answer the same purpose became essential. One was therefore contrived; and having been found in its earlier and ruder forms to be of great utility, it has since been improved in its appearance, as well as in the convenience of its management.

Elevation and Section of the Ventilating Stove.



Elevation.



Section.

These Stoves are composed of two cylinders, the *inner* containing a fire chamber, which is lined with soap stone or fire brick, while the *outer* constitutes a

chamber for warming the air, which is introduced into it beneath the inner cylinder, from an air box directly connected with the external atmosphere.

They possess the following advantages:—

1. They are in fact *furnaces*, having distinct and capacious air chambers.

2. They insure, when properly set, that *supply of fresh air*, which is *indispensable to the proper ventilation* of any apartment.

3. The Regulating Distributor, which is movable or fixed, as may be desired, determines with great accuracy the amount and temperature of the admitted air.

4. The outer cylinder is never hot enough to burn the person or clothing, or to be uncomfortable to those who are situated in its immediate vicinity.

5. They are constructed with the utmost regard to efficiency, durability, compactness, and neatness of appearance.

These Stoves have been furnished to the Schools whenever your Committee have required their use, and at manufacturers' prices, without any profit whatever to the Inventor and Patentee.

They may be used with advantage in the largest rooms, when the cellars are unfit for Furnaces, or when it is preferred to have the fire in the room itself. The Johnson, Wells, Hawes, and Winthrop School houses are warmed entirely by them.

Ventiducts. The discharging ventiducts have been made in various ways—some of wood, some of metal, and others of “lath and plaster.” Some have opened at the ceiling only, and in but one part of the room, while others have been equally divided at opposite sides of the apartment. Our rule is this:—If the Heating Apparatus is at one end of an oblong room,

the ventiduct is placed at the opposite. If the stove or furnace flue is at the middle of the longest side, the ventiducts are placed at each end, and are of course reduced to one half the size of the single one.

The *best* manner of constructing them is shown by the drawings, and described on page 33.

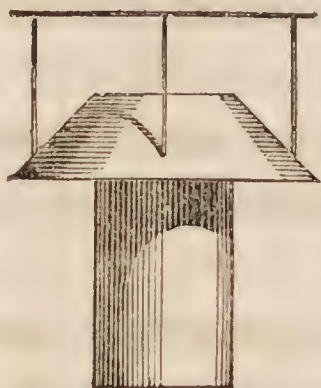
There is great economy in carrying the boxes to the floor in all cases. In this way the room can be kept warm and the air pure in the coldest and most windy days.

The registers at the top and bottom can be used separately or together, as may be desired. (See Appendix A.)

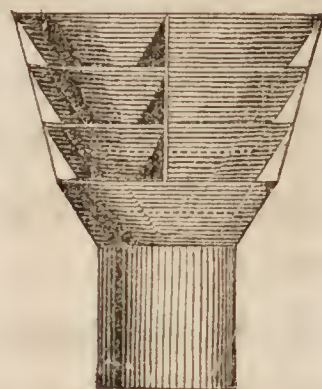
It is necessary and advantageous to apply some kind of cap or other covering upon the ventiducts where they terminate above the roof. It is necessary as a protection from the rain and the down blasts of wind, and it is also very advantageous to be enabled in this way to avail ourselves of the power of the wind to create an active upward current. We used at first the turncap or cowl invented by Mr. Espy, and with satisfactory results. It is undoubtedly the best movable top known ; but is noisy and somewhat liable to get out of working order. These objections to the movable tops have long been known, and various stationary tops have been invented and have been partially successful. An improved Stationary Top, or Ejecting Ventilator, as it is called, has been invented during the past year by Mr. Emerson, and is the apparatus to which we referred on page 16, of our first Report. It is shown in the drawing, and consists of a frustrum of a cone attached to the top of a tube, open in its whole extent, and surmounted by a fender which is supported upon rods, and answers the double purpose of keeping out the rain

and of so directing or turning a blast of wind upon the structure, as that in whatever direction it falls, the effect, that of causing a strong upward draft, will be very uniform and constant.

EJECTING VENTILATOR

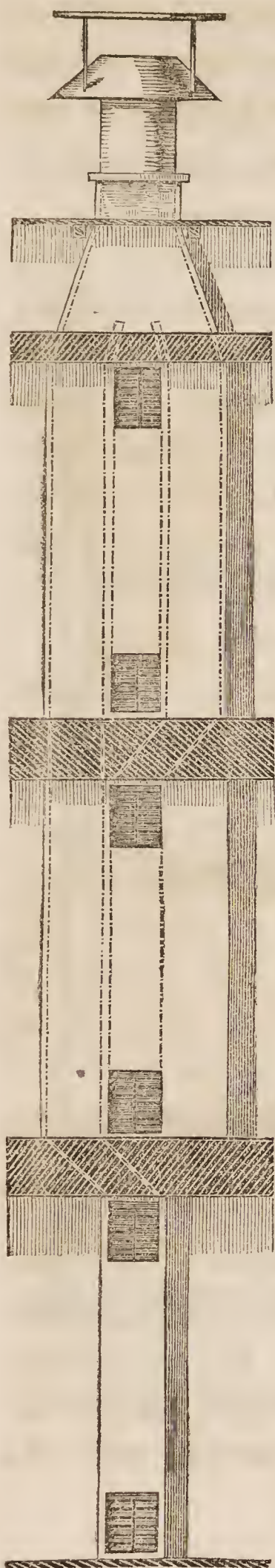


INJECTING VENTILATOR.



Being satisfied that this Stationary Ejector possessed all the advantages of the best tops hitherto known, without the disadvantages of either of them, we have adopted it for several of the houses last ventilated, and find it in all respects satisfactory. We therefore recommend it for general use.

The Injector may generally be dispensed with, but in situations unfavorable for introducing air, it may be sometimes found convenient, or even necessary.

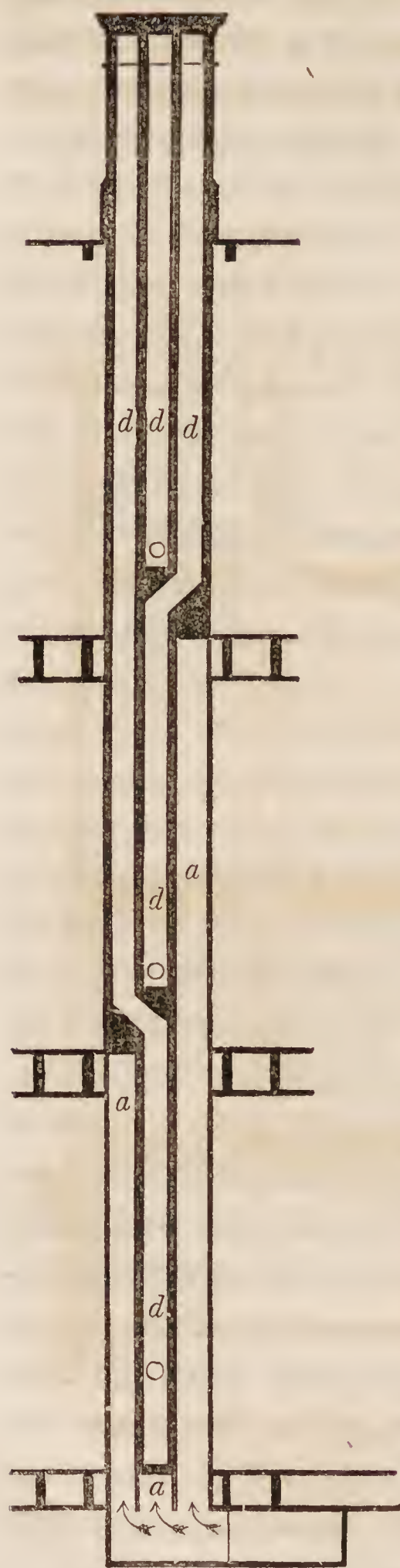


Elevation of Ventiducts.

The discharging ventiducts should be situated at the part of the rooms most distant from the stove or register of the furnace, and should always, if possible, be constructed in or upon an *interior* wall or partition, and an outer brick wall must if possible be avoided. They should be made of thoroughly seasoned sound pine boards, smoothed on the inner sides, and put together with two-inch iron screws. The outside finish may be of lath and plaster, or they may be projected backwards into a closet or entry, as shown in the Section.* They must be carried entirely to the floor, and should be fitted at the top and bottom with a swivel blind, or register, whose capacity is equal to that of the ventiduct into which it opens. This blind may be governed by stay rods or pulleys. The elevation in the margin gives a view of the ventiducts for a building of three stories, and shows the best mode of packing them, so as to avoid injuring the appearance of the rooms.

These ventiducts must be *kept entirely separate* to the main discharger at the roof, as any other arrangement would impair or destroy their utility.

* See page 35.



a. Cold air ducts.
d. Smoke flues.

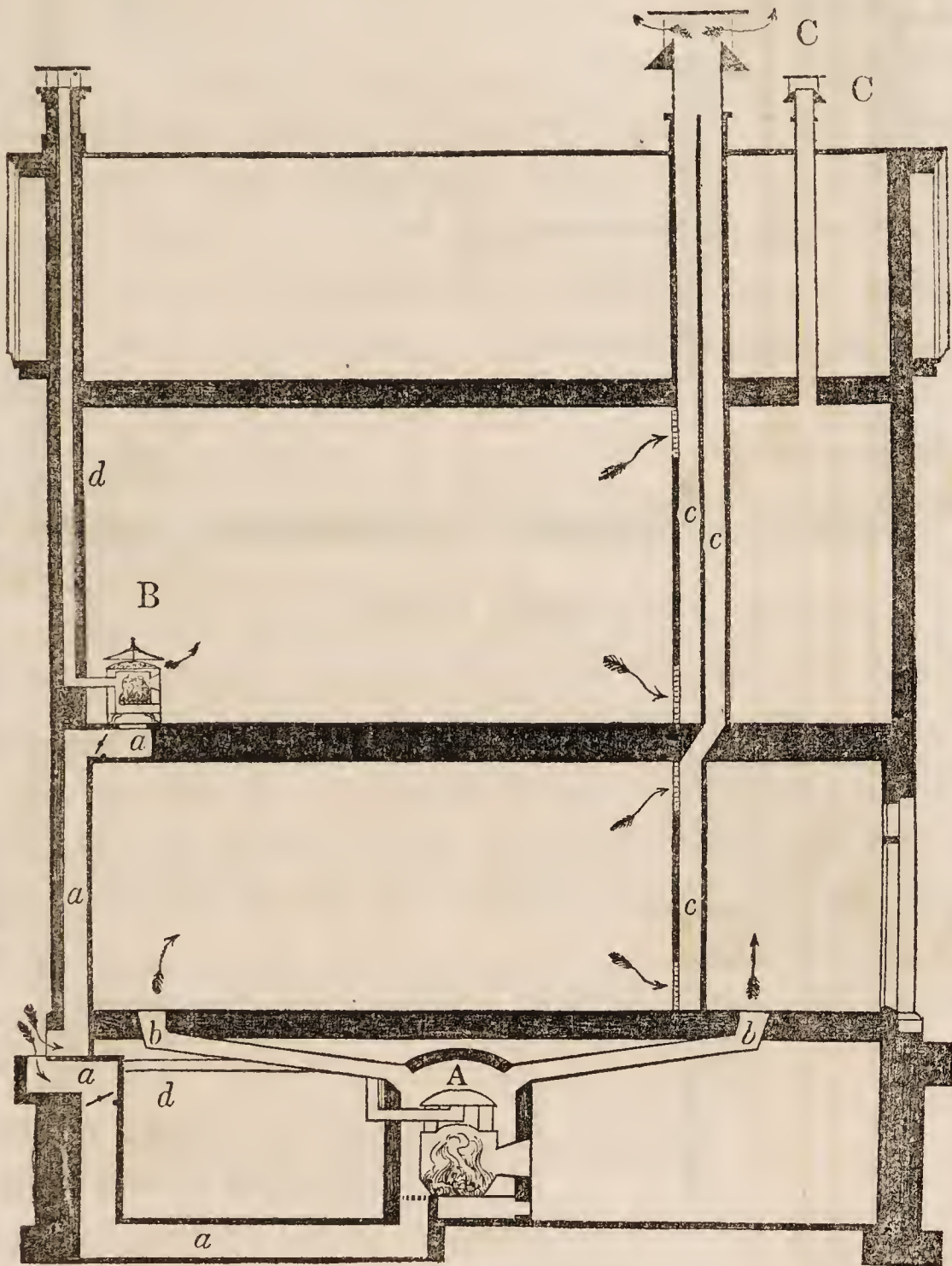
The size of the ventilators and ventiducts must correspond to the capacity of the room, and the number it is intended to accommodate.

A room containing sixty Scholars is found to require a discharging duct of fourteen inches in diameter. A room for one hundred Scholars requires the tube to be eighteen inches; and a room for two hundred Scholars requires it to be twenty-four inches.

The *fresh air ventiducts* should exceed in capacity those for carrying off the impure air by about *fifty per cent.*; so that there will then always be a surplus or plenum supply, and the little currents of cold air which press in at the crevices of the doors and windows will be entirely prevented.

The Section shown in the margin exhibits a very convenient mode of bringing the cold air to the ventilating stoves in a three story building in connection with the smoke flues.

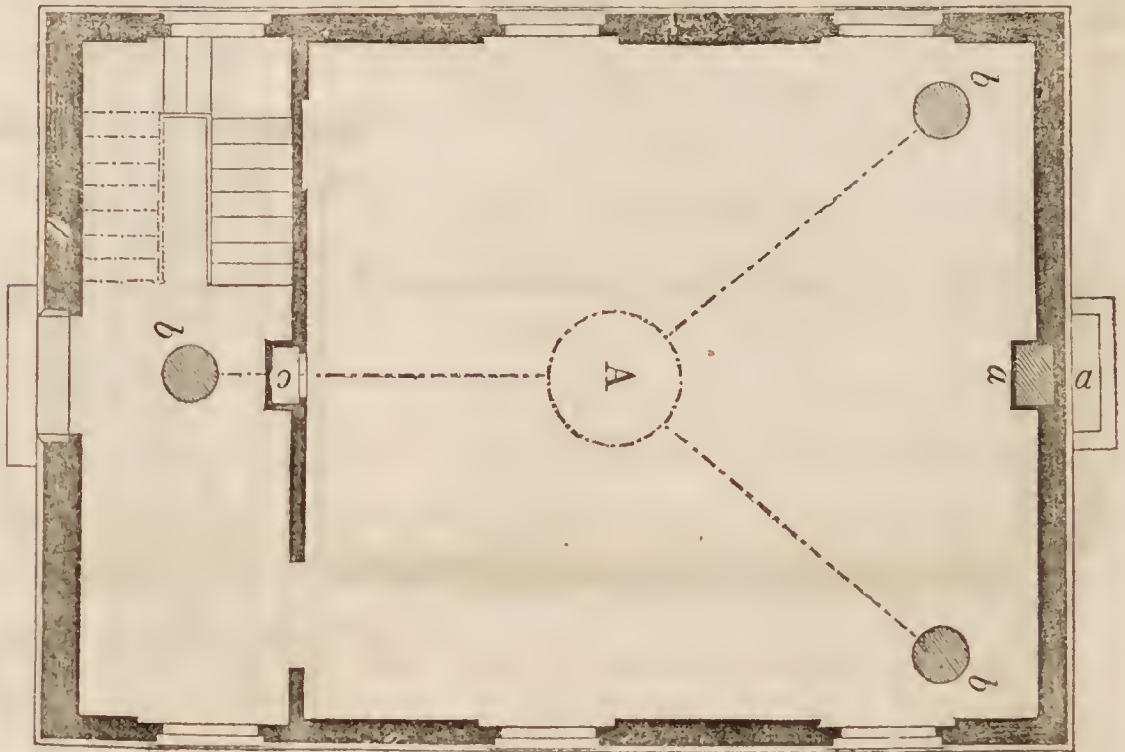
The following Section and Plans (See page 36) exhibit at one view an example of a building of two stories warmed and ventilated by the apparatus and in the manner recommended.



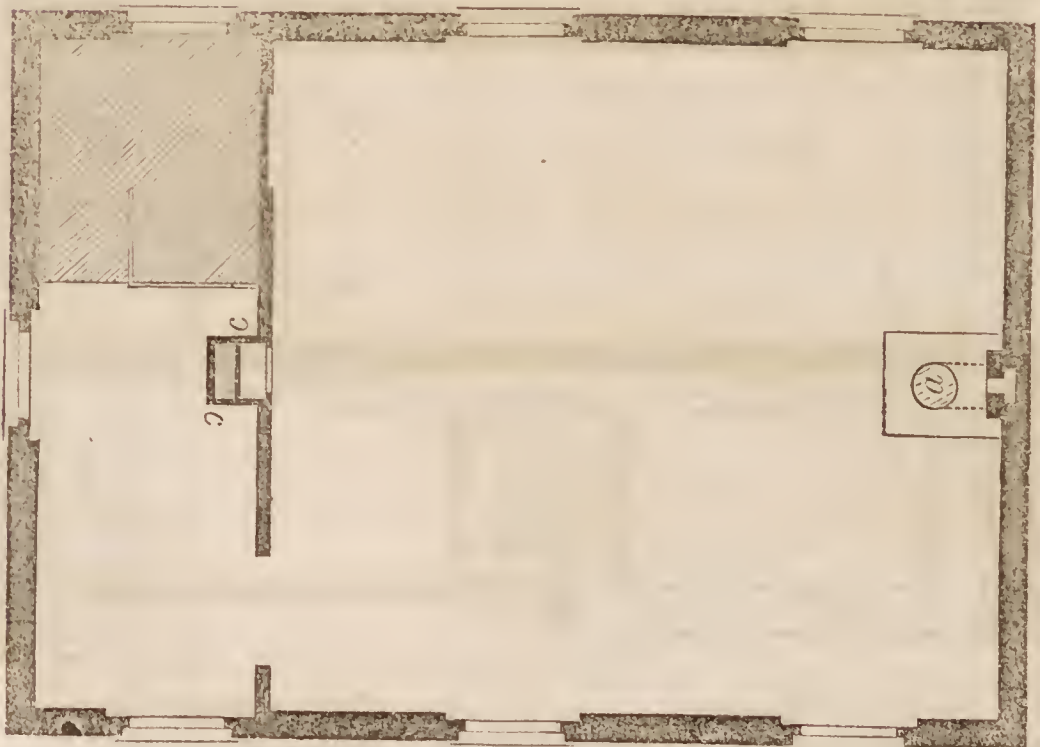
A. Chilson's Furnace.
B. The Boston School Stove.
C. Emerson's Ejector.

a. Cold or Fresh air ducts.
b. Warmed air ducts.
c. Impure air ducts.
d. Smoke flues.

Plans of first and second floors. The letters on the plans correspond to those in the Section.



FIRST FLOOR.



SECOND FLOOR.

- A.* Furnace.
- a. a. a.* Fresh air ducts.
- b. b. b.* Warm air registers.
- c. c. c.* Impure air ducts.

In the first Report it was estimated that the sum of \$250 would be sufficient to ventilate each School house. Our experience has justified this estimate—but we have found in the basement stories of these houses Branch or Primary Schools to the number of twenty-five, all of which have been ventilated. Allowing \$100 each for these, or charging off the cost of supplying and repairing heating apparatus, which we have been obliged to do, or discontinue our labors, and we shall still be much within our estimate. There are a few furnaces which require alterations, and one house, the Franklin, has not been ventilated; so that we think \$750 more should be asked for in addition to the \$2750, the sum which is required to settle the bills for ventilating the rooms named above.

We have appended to this Report directions for the management of the Stoves, Furnaces and Venti-ducts, to which the attention of the masters of the Public Schools is requested, in conformity to the rule of this Board which requires their attention to the Ventilation of the School houses under their care.*

We request the passage of the accompanying orders.

All which is respectfully submitted.

HENRY G. CLARK,
EDWARD G. LORING,
CHARLES BROOKS.

* See Appendix A.

CITY OF BOSTON.

In School Committee, Dec. 9, 1847.

THE Committee on Ventilation made a Report—to which was subjoined the following orders, viz :

Ordered, That the modes of ventilation and heating specified in the foregoing Report, be and hereby are recommended to the City Government for the use of the Boston Schools.

Ordered, That the City Council be requested to make an appropriation of \$3500 ; the said sum, or such part of it as may be necessary to complete the Ventilation of the School houses, to be subject to the order of the Sub-Committee of the School Committee upon the Ventilation of School houses.

Read, accepted, and the orders passed by a unanimous vote, and 500 copies ordered to be printed.

Attest,

S. F. McCLEARY, *Secretary*.

APPENDIX.

A.

Rules relative to the use of the Stoves, Furnaces and Ventiducts.

1. *To warm the room.* Close the upper, and open the lower registers of the ventiducts ; close the upper door of the stove or furnace and open the lower door.

2. *After the room is warmed.* Raise the distributing top of the stove from three to six inches ; close the lower door of the stove or furnace and open the upper door ; open all the registers of the ventiducts about half their width.

3. *If the room is too warm.* Open the registers full width, and raise the cover of the stove, keeping the upper door of the stove or furnace open, and the lower door closed.

4. *If the room becomes too cool.* Close the upper registers, (for a short time only ;) close the upper door of the stove and open the lower door ; drop the cover down within two inches of the sides.

5. Never close the top of the stove entirely down, while there is any fire therein.

6. At night, on leaving the room, let the cover of the stove down within one inch of the sides ; close the lower door of the furnace or stove and open the upper one ; place all the registers open about half their width.

7. The valves in the cold air ducts must *never* be entirely closed while there is any fire in the stoves or furnaces to which they lead.

8. *The windows must not be opened to cool the room ; but the fire should be diminished,* or the principal door may be opened for a short time.

B. *See pages 14 and 27.*

THE following extracts are made from a note furnished by Dr. Wyman* to your Committee at their request, and for which they desire to express to him their obligations.

The answer to the first question, as quoted here, is a *mere synopsis of that given*, but is in the words of Dr. Wyman. The others are in full.

“ Question I. The chemical changes produced in air exposed in the chamber of a hot air furnace to an iron surface at a red-heat (800°—1000°F.) ?

“ The changes produced under the circumstances stated in the query would be; the dryness, and the products of the more or less perfect combustion of animal or vegetable matter — carbonic acid and the other constituents of smoke.

“ Question II. Would there be any changes in such air which would render it injurious to the health of persons who depended upon it to supply their lungs for respiration ?

“ The dryness would undoubtedly be injurious and produce many unpleasant sensations, the most prominent of which would be dryness of the lips and skin, and inflammation of the eyes. The products of the combustion of the impurities of the air, *if in sufficient quantity*, would produce the usual effects of carbonic acid gas, head-ache and drowsiness ; the other products would produce irritation of the eyes, nose and lungs.

“ Question III. The consequences of letting into the air chamber of a furnace large quantities of the gases produced by the combustion of anthracite coal ?

“ These consequences must be injurious in proportion to the quantity of the gases admitted ; they are deadly poisons ; and when mingled with the air passing through the furnace and ascending to the apartments which it supplies cannot but be injurious to those whose lungs they enter. Not long since a man and boy in Salem lost their lives from entering a room into which the gases from burning anthracite had been driven by the wind. Too much care cannot be taken to prevent the escape of such gases into the air-chamber.

“ I am very respectfully,

“ Your obedient Servant,

“ MORRILL WYMAN.

“ *Cambridge, Nov. 19, 1847.*”

* Author of “ Practical Treatise on Ventilation.”

C.

THE following note has been received from Mr. Hammond, a Master Mason, who has had more experience in repairing and setting Furnaces in the Boston School Houses than any other person.

“SIR,

“IN compliance with your request, I submit to you what has come under my observation respecting the use of cast iron Cylinders (fire pots) in furnaces.

“In the winter of 1845, I was called to put in two new Cylinders at the Mather School House. Last winter, another was required; and now it is necessary to put in two more.

“At the Dwight School House, in January, 1847, I set two new Cylinders, and before the expiration of the winter they were not fit for use.*

“The expense of a new Cylinder averages about \$14.

“I remain, sir,

“Yours, with high respect,

“J. HAMMOND.

“Nov. 15, 1847.”

D.

See pages 16, 27 and 28.

Extracts from a report on the Mayhew School Furnaces, made to the School Board, by J. M. Wightman, Esq.

“The furnace of Messrs. Bryent & Herman is entirely of cast iron—the fire pot is very thick, and armed upon the outside with a number of projecting points to radiate the heat. The cold air box and hot air tube are much smaller than in Mr. Chilson’s, and as the air is admitted near the fire pot, which is generally red hot, the room is warmed by the diffusion of a comparatively small quantity of *highly heated* air passing into it.

“The furnace of Mr. Chilson is of thick plate iron, having a more shallow fire pot of cast iron, lined with soap stone, which effect-

* The Furnaces here referred to have been displaced by order of the Committee on Public Buildings.

ually prevents its becoming red hot. The air is let into the furnace chamber, and from thence to the School room, in sufficient volume to supply the whole demand of the School for fresh air, the air boxes being much larger than in any other furnace. By this arrangement, an immense quantity of warmed air is constantly passing through the School room, and the rapidity with which the air is changed, and an equal temperature kept in the School, are worthy of notice.

“On Monday, the 27th instant, the weather being very cold, the effect of the two furnaces in warming their several rooms was very apparent. When the School commenced at 9 o'clock, the temperature of the upper room, warmed by Mr. Chilson's furnace, was 68° , while that of the room warmed by the furnace of Messrs. Bryant & Herman was at 55° . Both the fires were made at the same time, and had been burning with a full draft. Mr. Chilson's furnace was slightly red on the top; but as the School was sufficiently warmed, the draft of this furnace was shut off, while that of Messrs. Bryant & Herman was kept on during the morning to procure the necessary heat.

“Without entering further into a comparison of these two furnaces, the Committee would state that they fully concur with the views of the “Committee on Ventilation,” in giving the preference to the furnace constructed by Mr. Chilson—and among other reasons, because experience has shown that there is no danger of the fire pot being broken or destroyed, so as to let the noxious gas from the coal into the air chamber—that they believe plate iron, sufficiently thick to be durable, will more rapidly transmit the heat of the fire than cast iron, which must be much thicker—and from their observations, the room is warmed much quicker—the purity of the air is greater—and the Ventilation is more perfect than with the other.”

Elevation of Mr. Chilson's Furnace referred to on page 27.

